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This listing of claims will replace all prior versions, and listings, of claims in the application:

Claim 1 (canceled)

1 Claim 2 (currently amended): An orthogonal frequency division  
2 multiplexing (OFDM) communication device, comprising:  
3 an OFDM receiver for receiving an OFDM signal  
4 containing a multitone synchronization signal;  
5 a synchronization interval sampler coupled to said  
6 receiver;  
7 an initial time and frequency offset estimator  
8 connected to said sampler and said receiver; and  
9 a frequency offset estimate refinement unit connected  
10 to said receiver, said sampler and said estimator,  
11 wherein a reference multitone synchronization signal  
12 is used by said estimator and said refinement device in  
13 calculating a time offset and a frequency offset of said  
14 multitone synchronization signal, said receiver utilizing said  
15 time offset and said frequency offset to synchronize with said  
16 received OFDM signal, and  
17 ~~The system of claim 1,~~  
18 wherein said initial time and frequency offset  
19 estimator comprises:  
20 a plurality of smoothed time-domain correlation  
21 estimators for outputting a series of time offset estimate and  
22 correlation estimate pairs, each pair related to a frequency  
23 offset estimate; and

24 a selector for selecting a selected time offset  
25 estimate and a selected initial frequency offset based in part  
26 upon the selection of the frequency offset estimate and time  
27 offset estimate that corresponds with the largest value of  
28 correlation estimate.

29 ~~The system of claim 2, wherein each of said smoothed time domain~~  
30 ~~correlation estimators comprises:~~

31 ~~a time domain correlator;~~

32 ~~a smoothing filter connected to said time domain~~  
33 ~~correlator and receiving an output from said time domain~~  
34 ~~correlator; and~~

35 ~~a maximum detector connected to and receiving an~~  
36 ~~output from said smoothing filter for detecting a signal energy~~  
37 ~~maxima representing a time estimate at which the energy of said~~  
38 ~~reference multitone synchronization signal is at a maximum.~~

1 Claim 3 (original): The system of claim 2, wherein the initial  
2 time and frequency offset estimator uses a coarse frequency  
3 discretization using  $F$  candidate frequency offsets.

1 Claim 4 (original): The system of claim 2, wherein said  
2 reference multitone synchronization signal has a length of  $T$ ,  
3 and wherein said frequency offset estimate refinement device  
4 comprises:

5 a  $T$ -length interval extractor for extracting a  $T$ -  
6 length sample of the output of said sampler;

7 a numerical oscillator for generating a complex  
8 exponential of a candidate frequency offset;

9           a multiplier for multiplying said T-length sample with  
10       said complex exponential to obtain a frequency shifted  
11       received signal;  
12           a correlator for correlating said frequency shifted  
13       received signal with said reference multitone  
14       synchronization signal and producing a correlation output;  
15       and  
16           a numerical optimizer for receiving said correlation  
17       output and outputting a new frequency offset candidate.

1   Claim 5 (currently amended): The system of claim 5 4, wherein  
2   said new frequency offset candidate and a time offset associated  
3   with said new frequency offset candidate are used by said  
4   receiver if said new frequency offset candidate is a candidate  
5   that yields a maximum correlation output.

Claim 6 (canceled)

1   Claim 7 (currently amended): The system of claim 2, wherein  
2   each of said smoothed time domain correlation estimators  
3   comprises:  
4       a time domain correlator;  
5       a smoothing filter connected to said time domain  
6   correlator and receiving an output from said time domain  
7   correlator; and  
8       a maximum detector connected to and receiving an  
9   output from said smoothing filter for detecting a signal energy

10 maxima representing a time estimate at which the energy of said  
11 reference multitone synchronization signal is at a maximum.  
12 ~~a time domain correlation estimator for receiving said received~~  
13 ~~signal transform and said reference signal transform and said~~  
14 ~~initial frequency offset estimate and outputting a time offset~~  
15 ~~estimate.~~

1 Claim 8 (original): A method of synchronizing an orthogonal  
2 frequency division multiplexing (OFDM) receiver with a received  
3 OFDM signal comprising a multitone synchronization signal,  
4 comprising the steps of:

5 obtaining a coarse time offset estimate of said  
6 received signal;

7 sampling said received signal in a selected time  
8 interval to derive samples of said multitone synchronization  
9 signal;

10 analyzing said samples with respect to a reference  
11 multitone synchronization signal to obtain, for each sample  
12 analyzed, a time offset, a frequency offset, and a signal  
13 energy;

14 selecting a one of said analyzed samples with the  
15 greatest signal energy to yield a selected time offset estimate  
16 and a selected frequency offset estimate for use by said  
17 receiver in synchronizing with said received OFDM signal.

1 Claim 9 (original): The method of claim 8, further comprising  
2 passing said selected time offset estimate and said selected  
3 frequency offset estimate to said receiver for use by said  
4 receiver in synchronizing with said received OFDM signal.

1 Claim 10 (original): A method of carrying out OFDM  
2 communications comprising:  
3 receiving an OFDM signal including within it a  
4 multitone synchronization signal;  
5 locating said synchronization signal within said OFDM  
6 signal;  
7 determining a time offset value of said  
8 synchronization signal;  
9 determining an initial frequency offset value of said  
10 synchronization signal; and  
11 recursively refining said frequency offset estimate to  
12 yield a selected pair of time and frequency offset values to be  
13 used by said OFDM receiver.

1 Claim 11 (original): The method of claim 10, wherein said  
2 initial time offset value and said initial frequency offset  
3 value are determined by obtaining a correlation with a stored  
4 reference value of said synchronization signal.

1 Claim 12 (original): The method of claim 11, wherein said  
2 correlation is performed seeking a maximum received  
3 synchronization signal energy level.

Claim 13-14 (canceled)

1 Claim 15 (currently amended): An orthogonal frequency division  
2 multiplexing (OFDM) communication device, comprising:

3           means for receiving an OFDM signal containing a  
4   multitone synchronization signal;

5           means, coupled to said receiving means, for sampling a  
6   synchronization interval of said OFDM signal;

7           means, connected to said sampling means and said  
8   receiving means, for obtaining an initial time estimate and an  
9   initial frequency offset estimate of said OFDM signal;

10          means, connected to said receiving means, said  
11   sampling means and said estimating means, for obtaining a  
12   frequency offset estimate refinement;

13          storage means, connected to said estimating means and  
14   said refinement means, for storing a reference multitone  
15   synchronization signal for use by said estimating means and said  
16   refinement means in calculating a time offset and a frequency  
17   offset of said multitone synchronization signal, said receiving  
18   means utilizing said time offset and said frequency offset to  
19   synchronize with said received OFDM signal;

20          ~~The system of claim 14, wherein said estimating means~~  
21   ~~further comprises:~~

22          a plurality of means for obtaining smoothed time-  
23   domain (TDC) correlation estimates, said smoothed TDC estimate  
24   means outputting a series of time offset estimate and  
25   correlation estimate pairs, each pair related to a frequency  
26   offset estimate; and

27          means for selecting a selected time offset estimate  
28   and a selected initial frequency offset based in part upon the  
29   selection of the frequency offset estimate and time offset  
30   estimate that corresponds with the largest value of correlation  
31   estimate.

1 Claim 16 (original): The system of claim 15, wherein each of  
2 said smoothed TDC estimate means comprises:  
3 a time domain correlator;  
4 a smoothing filter connected to said time domain  
5 correlator and receiving an output from said time domain  
6 correlator; and  
7 a maximum detector connected to and receiving an  
8 output from said smoothing filter for detecting a signal energy  
9 maxima representing a time estimate at which the energy of said  
10 reference multitone synchronization signal is at a maximum.

1 Claim 17 (original): The system of claim 16, wherein the  
2 estimating means uses a coarse frequency discretization using  $F$   
3 candidate frequency offsets.

1 Claim 18 (original): The system of claim 15, wherein said  
2 reference multitone synchronization signal has a length of  $T$ ,  
3 and wherein said refinement means comprises:  
4 a  $T$ -length interval extractor for extracting a  $T$ -  
5 length sample of the output of said sampler;  
6 a numerical oscillator for generating a complex  
7 exponential of a candidate frequency offset;  
8 a multiplier for multiplying said  $T$ -length sample with  
9 said complex exponential to obtain a frequency shifted received  
10 signal;  
11 a correlator for correlating said frequency shifted  
12 received signal with said reference multitone synchronization  
13 signal and producing a correlation output; and

14 a numerical optimizer for receiving said correlation  
15 output and outputting a new frequency offset candidate.

1 Claim 19 (original): The system of claim 18, wherein said new  
2 frequency offset candidate and a time offset associated with  
3 said new frequency offset candidate are used by said receiving  
4 means if said new frequency offset candidate is a candidate that  
5 yields a maximum correlation output.

Claim 20 (canceled)

1 Claim 21 (original): A device for synchronizing an orthogonal  
2 frequency division multiplexing (OFDM) receiver with a received  
3 OFDM signal comprising a multitone synchronization signal,  
4 comprising:  
5 means for obtaining a coarse time offset estimate of  
6 said received signal;  
7 means for sampling said received signal in a selected  
8 time interval to derive samples of said multitone  
9 synchronization signal;  
10 means for analyzing said samples with respect to a  
11 reference multitone synchronization signal to obtain, for each  
12 sample analyzed, a time offset, a frequency offset, and a signal  
13 energy; and  
14 means for selecting one of said analyzed samples with  
15 the greatest signal energy to yield a selected time offset  
16 estimate and a selected frequency offset estimate, wherein said  
17 selected time offset estimate and said selected frequency offset



18 estimate are used by said receiver in synchronizing with said  
19 received OFDM signal.

1 Claim 22 (original): The device of claim 21, further comprising  
2 means for passing said selected time offset estimate and said  
3 selected frequency offset estimate to said receiver for use by  
4 said receiver in synchronizing with said received OFDM signal.

1 Claim 23 (original): A device for carrying out OFDM  
2 communications comprising:  
3 means for receiving an OFDM signal including within it  
4 a multitone synchronization signal;  
5 means for locating said synchronization signal within  
6 said OFDM signal;  
7 means for determining a time offset value of said  
8 synchronization signal;  
9 means for determining an initial frequency offset  
10 value of said synchronization signal; and  
11 means for recursively refining said frequency offset  
12 estimate to yield a selected pair of time and frequency offset  
13 values to be used by said OFDM receiver.

1 Claim 24 (original): The device of claim 23, wherein said  
2 initial time offset value and said initial frequency offset  
3 value are determined by obtaining a correlation with a stored  
4 reference value of said synchronization signal.

1 Claim 25 (original): The device of claim 24, wherein said  
2 correlation is performed seeking a maximum received  
3 synchronization signal energy level.

Claim 26-28 (canceled)

1 Claim 29 (currently amended): An OFDM signal processor  
2 comprising:  
3 an OFDM receiver for receiving an OFDM signal  
4 containing a multitone synchronization signal;  
5 a synchronization interval sampler connected to said  
6 input and said receiver;  
7 an initial time and frequency offset estimator  
8 connected to said sampler and said receiver; and  
9 a frequency offset estimate refinement device  
10 connected to said receiver, said sampler and said estimator,  
11 wherein a reference multitone synchronization  
12 signal is used by said estimator and said refinement device in  
13 calculating a time offset and a frequency offset of said  
14 multitone synchronization signal, said receiver utilizing said  
15 time offset and said frequency offset to synchronize with said  
16 received OFDM signal, and  
17 ~~The processor of system of claim 27,~~  
18 wherein said initial time and frequency offset  
19 estimator comprises:  
20 a plurality of smoothed time-domain  
21 correlation estimators for outputting a series of time offset  
22 estimate and correlation estimate pairs, each pair related to a  
23 frequency offset estimate; and

24                   a selector for selecting a selected time  
25   offset estimate and a selected initial frequency offset based in  
26   part upon the selection of the frequency offset estimate and  
27   time offset estimate that corresponds with the largest value of  
28   correlation estimate.

1   Claim 30 (original): The processor of claim 29, wherein each of  
2   said smoothed time domain correlation estimators comprises:

3                   a time domain correlator;

4                   a smoothing filter connected to said time domain  
5   correlator and receiving an output from said time domain  
6   correlator; and

7                   a maximum detector connected to and receiving an  
8   output from said smoothing filter for detecting a signal energy  
9   maxima representing a time estimate at which the energy of said  
10   reference multitone synchronization signal is at a maximum.

1   Claim 31 (original): The processor of claim 29, wherein the  
2   initial time and frequency offset estimator uses a coarse  
3   frequency discretization using  $F$  candidate frequency offsets.

1   Claim 32 (original): The processor of claim 29, wherein said  
2   reference multitone synchronization signal has a length of  $T$ ,  
3   and wherein said frequency offset estimate refinement device  
4   comprises:

5                   a  $T$ -length interval extractor for extracting a  $T$ -  
6   length sample of the output of said sampler;

7 a numerical oscillator for generating a complex  
8 exponential of a candidate frequency offset;

9 a multiplier for multiplying said T-length sample with  
10 said complex exponential to obtain a frequency shifted received  
11 signal;

12 a correlator for correlating said frequency shifted  
13 received signal with said reference multitone synchronization  
14 signal and producing a correlation output; and

15 a numerical optimizer for receiving said correlation  
16 output and outputting a new frequency offset candidate.

1 Claim 33 (original): The processor of claim 32, wherein said  
2 new frequency offset candidate and a time offset associated with  
3 said new frequency offset candidate are used by said receiver if  
4 said new frequency offset candidate is a candidate that yields a  
5 maximum correlation output.

1 Claim 34 (original): The processor of claim 32, wherein said  
2 initial time and frequency offset estimator comprises:

3 a first Fast Fourier Transformer for obtaining a  
4 transform of said received signal;

5 an second Fast Fourier Transformer device for  
6 obtaining a transform of said reference multitone  
7 synchronization signal;

8 a frequency domain correlation estimator for receiving  
9 said received signal transform and said reference signal  
10 transform and outputting an initial frequency offset estimate;  
11 and

12 a time domain correlation estimator for receiving said  
13 received signal transform and said reference signal transform  
14 and said initial frequency offset estimate and outputting a time  
15 offset estimate.

1 Claim 35 (original): An OFDM transmitter comprising:  
2 means for transmitting an OFDM signal comprising a  
3 first time interval and a second time interval;  
4 means for transmitting data at one or more data  
5 frequencies during said first time interval; and  
6 means for transmitting, during said second time  
7 interval, a synchronization tone, at one or more synchronization  
8 frequencies, for a predetermined time period, the frequencies of  
9 said synchronization tone being distinct from said data  
10 frequencies.

1 Claim 36 (original): A method for transmitting an OFDM signal  
2 comprising the steps of:  
3 transmitting an OFDM signal comprising a first time  
4 interval and a second time interval;  
5 means for transmitting data at one or more data  
6 frequencies during said first time interval; and  
7 means for transmitting, during said second time  
8 interval, a synchronization tone, at one or more synchronization  
9 frequencies, for a predetermined time period, the frequencies of  
10 said synchronization tone being distinct from said data  
11 frequencies.

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